

Exploring Green Skills Among Pre-service Teachers in the Philippines: Insights from a Self-report Assessment

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Abstract

As the global shift toward sustainability accelerates, education systems play a pivotal role in equipping future teachers with the competencies needed for a green economy. This study seeks to evaluate the level of green skills among pre-service teachers in the Philippines. Employing a descriptive-comparative research design, the study utilized a self-report survey to assess the green skills of 203 pre-service teachers enrolled in a large university in the Philippines. The descriptive approach provided a snapshot of respondents' perceived competencies, while the comparative design examined differences by gender and academic program using an independent-samples t-test and Welch's one-way ANOVA, respectively. Findings revealed no significant differences in green skills between male and female respondents; however, meaningful variations were observed among academic programs, with relatively stronger performance among pre-service teachers in the Bachelor of Secondary Education major in Science, the Bachelor of Technology and Livelihood Education, and the Bachelor of Technical-Vocational Teacher Education. This may be associated with the nature of their curricula, which expose students to sustainability-related concepts, experiential learning, technical applications, and environmentally responsible practices. In contrast, weaker performance was observed among students from the Bachelor of Elementary Education and Bachelor of Secondary Education majors in Mathematics. These results suggest that curricular orientation and training experiences have a stronger impact on the development of green skills, highlighting the need for targeted curricular integration and the continuous enhancement of teacher education programs to strengthen these competencies.

Keywords: Green Skills, Pre-service Teachers, Sustainability, Teacher Education Programs.

Introduction

Green skills are increasingly recognized as essential in building a sustainable future. The concept of green skills encompasses the knowledge, abilities, values, and attitudes necessary to promote sustainable development and environmental stewardship (1). In education, these skills are vital for preparing future generations to respond to global challenges such as climate change, resource depletion, and biodiversity loss. As schools increasingly recognize the importance of sustainability, integrating green skills into teacher preparation programs has become essential for cultivating environmental awareness and responsible citizenship (2). Green skills extend beyond technical expertise in environmental fields. They include problem-solving, teamwork, creativity, and entrepreneurial thinking—competencies needed to adapt to the growing green economy (3). A group identified nine essential elements of green skills, including

communication, intellectual, self-development, learning, and career skills, as well as environmental awareness, Science, Technology, Engineering, and Mathematics (STEM) proficiency, and entrepreneurship (4). These competencies together form a comprehensive framework for equipping learners to contribute to sustainable societies.

Globally, education systems have begun embedding sustainability principles into curricula and teacher training. Countries such as Scotland and Finland have institutionalized sustainability education across all levels, linking policy, curriculum, and teacher development (5, 6). However, in the Philippines, sustainability efforts are characterized by a significant systemic gap, as they currently operate in silos rather than as a cohesive continuum. While the Department of Education has integrated practical environmental projects, such as school garden and disaster response, into

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the K-12 curriculum (7, 8), these remain primarily "downstream" applications that lack an "upstream" foundation in teacher education. Unlike Scotland or Finland, where sustainability is institutionalized across all levels of the system to link policy and teacher development (5, 6), the Philippine model focuses on student-facing activities without simultaneously updating the pedagogical training of the educators who lead them. This creates a disconnect in which teachers are expected to implement green initiatives, even though Philippine programs have yet to systematically embed green competencies into teacher education (9).

This failure to bridge the gap is further highlighted when compared to neighboring Asian systems. In Malaysia, teacher training in environmental sustainability is already well-established, ensuring that educators enter the workforce with the necessary expertise to deliver curricula (10). Similarly, China has utilized international partnerships, such as those with the UNESCO-UNEVOC International Centre, to specifically strengthen higher technical institutions and align green skills with national development goals (9). In contrast, the Philippine approach remains gradual and fragmented; the focus on localized, school-based measures has not yet translated into a comprehensive framework for green skills (11). Consequently, the lack of systemic integration in higher education means that school-level sustainability efforts often remain isolated projects rather than becoming a deeply rooted, professionalized standard of teaching.

Studies reveal that while Filipino students and teachers express positive attitudes toward environmental issues, their knowledge and practical application of sustainability concepts remain moderate (12, 13). Moreover, existing environmental education tends to focus on awareness rather than on developing employable green skills relevant to the modern economy (14). This underscores a national gap between policy intentions and actual pedagogical practice.

Teacher education institutions play a pivotal role in bridging this gap. Pre-service teachers, as future educators, are expected to possess the competencies necessary to integrate sustainability into their teaching and professional practices (15). The Philippine teacher education is guided by competency-based frameworks such as the

Philippine Professional Standards for Teachers (PPST) and the Philippine Qualifications Framework (PQF). The PPST serves as the national framework for teacher quality and professional development, defining the expectations for teachers across career stages in terms of content knowledge, pedagogy, learning environment, diversity of learners, curriculum and planning, assessment, community engagement, and professional growth (16). Meanwhile, the PQF establishes a national qualifications structure that describes the learning outcomes expected of graduates at different levels of education, ensuring alignment between education, training, and labor market requirements in terms of knowledge, skills, and competencies (17). Despite these structured frameworks, sustainability-oriented competencies and green skills remain insufficiently institutionalized within teacher preparation standards and curricular implementation. Furthermore, many Philippine teacher education programs, particularly in disciplines other than science and technical-vocational areas, still lack structured courses dedicated to green skills development (18-21). Studies in Philippine teacher education further indicate that while pre-service teachers generally demonstrate positive environmental attitudes, their environmental literacy, instructional readiness, and sustainability integration competencies remain only moderate (22, 23). As a result, graduating students may enter the workforce without sufficient preparation to promote sustainability effectively in classrooms and communities.

Given these conditions, this study seeks to evaluate the level of green skills among preservice teachers in the Philippines through a self-assessment approach. It aims to explore the depth of their understanding, the extent to which they can translate knowledge into practice, and their preparedness to advance sustainable teaching in their future classrooms. While self-assessment may not directly measure actual performance or observable skills, it remains a valuable method for capturing individuals' perceived competencies, self-efficacy, and reflective awareness (22, 23). By identifying current competencies and areas for improvement, the study aims to provide evidence to inform curriculum enhancement and teacher training initiatives. Ultimately, the research contributes to ongoing national and global efforts

to strengthen sustainability education and align teacher preparation with the demands of a green and resilient economy.

Methodology

Design

This study employed a descriptive-comparative research design using a self-report survey to assess the green skills of pre-service teachers. The descriptive approach was selected to provide a snapshot of the current state of pre-service teachers' competencies in green skills, as perceived by the respondents themselves. Comparative design was also applied to compare students' green skills across programs and gender.

Respondents

The respondents of the study were pre-service teachers enrolled in various education programs at a university in the Eastern Visayas region (approximate GPS coordinates: 11° N, 125° E) of the Philippines. A stratified random sampling technique was used to ensure that students from various specializations were adequately represented. A total of 203 respondents were selected for the study, with sample sizes proportionate to the total enrollment in each program. With a total of 44 students, the Bachelor of Elementary Education (BEED) has the most students enrolled, closely trailing is Bachelor of Physical Education (BPED) with 40 students. The Bachelor of Technology and Livelihood Education (BTLED) program has 31 students enrolled, while the Bachelor of Technical Vocational Teacher Education (BTVTED) program has 22 students. Both the Bachelor of Culture and Arts Education (BCAED) and the Bachelor of Secondary Education major in Mathematics (BSED Math) have 21 students, while the Bachelor of Secondary Education major in Science (BSED Science) has 24 students. Looking at the data by sex, there are 136 female students (67%) and 67 male students (33%).

Instrument

The instrument used to assess respondents' green skills was adapted from a past study (24). The survey consisted of items related to different

dimensions of green skills, including understanding of knowledge (UND), mastery of skills (MAS), application of skills (APP), and skills development (DEV). Respondents were asked to rate their skills on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The instrument was chosen for its relevance to the context of green skills education and its ability to capture a range of skills pertinent to sustainability. The content validity of the green skills scale was established through expert review by faculty members specializing in environmental education. Their feedback was used to refine the questions to ensure clarity, relevance, and alignment with the study objectives. Reliability and confirmatory factor analysis were also performed using Jamovi software. For reliability, Cronbach's alpha coefficients for each construct were as follows: UND ($\alpha = .836$), MAS ($\alpha = .913$), APP ($\alpha = .908$), and DEV ($\alpha = .908$). The overall scale demonstrated excellent reliability, with a total Cronbach's alpha of .949.

To assess construct validity, a confirmatory factor analysis using robust maximum likelihood (MLR) was conducted in Jamovi. Based on the results, all factor loadings are statistically significant ($p < .001$) and have strong standardized factor loadings. The standardized factor loadings for each construct are presented in Figure 1. For UND, standardized factor loadings ranged from .66 to .82. For MAS, loadings ranged from .81 to .92. APP items loaded between .81 and .88, while DEV loadings ranged from .80 to .88. The measurement model demonstrated good overall fit to the data. Although the chi-square statistic was significant, $\chi^2(98) = 144$, $p = .002$, this result is common in large samples and was addressed using robust corrections. The scaled root mean square error of approximation (RMSEA) was .048 with a 95% confidence interval of [.034, .061], indicating good fit. The standardized root mean square residual (SRMR) was .040, indicating an excellent fit. Incremental fit indices were above recommended thresholds, including the robust comparative fit index (CFI) of .97 and Tucker-Lewis's index (TLI) of .965.

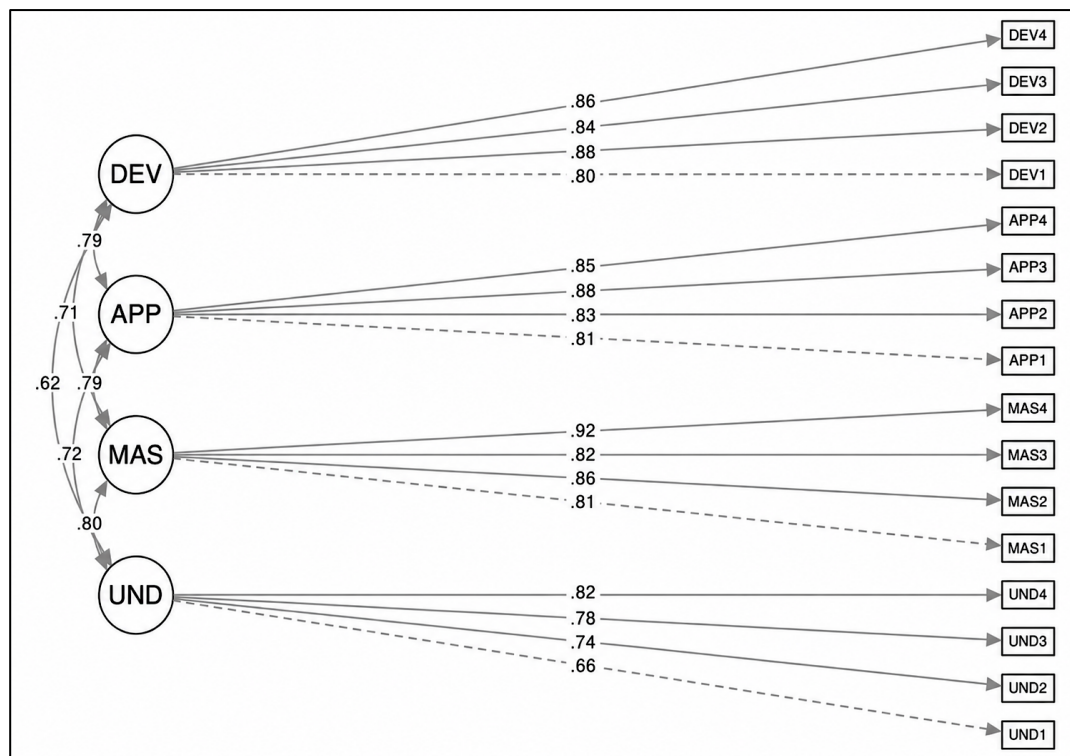


Figure 1: Path Diagram of the Green Skills Scale

Data Collection

Data was collected over a period of one month. The researchers coordinated with program heads to disseminate the survey to the selected respondents. An online survey platform was used to facilitate distribution and collection. The respondents were briefed on the purpose of the study and assured that their responses would be kept confidential and used solely for research. Participation was voluntary, and informed consent was obtained prior to participation. After the respondents gave consent, they were instructed to complete the survey questionnaire. All completed questionnaires were stored securely.

Data Analysis

The data collected were analyzed using descriptive statistics to determine the means and standard deviations for each dimension of green skills. Independent-samples t-test and Welch’s one-way ANOVA were used to examine differences in green skills between genders and across programs, respectively. The significance level was set at $p < .05$. Initial diagnostic checks showed that the normality assumption for a one-way ANOVA was not met; however, the statistical test is robust to violations. In addition, Levene’s test revealed a violation of the assumption of the homogeneity of

variances; thus, Welch’s one-way ANOVA was deemed more appropriate to be used. When the omnibus F-test was significant, Games-Howell post hoc tests were performed to determine which groups differed significantly. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Version 31.

Results

Table 1 presents the descriptive statistics, such as mean and variance, for the four constructs: Understanding of Knowledge, Mastery of Skills, Application of Skills, and Skills Development, categorized by gender and academic program. Based on the table, female students exhibited slightly higher means across all constructs than male students. Furthermore, the standard deviations were slightly higher among males, indicating somewhat greater variability in responses. Among programs, BSED Science had the highest mean scores across all constructs, while BSED Math reported the lowest. Additionally, the standard deviation values suggest that responses were more consistent in some programs (e.g., BPED, BSED Science) than in others (e.g., BEED), with higher variance in some constructs.

Table 1: Descriptive Statistics of the Green Skills Across Gender and Academic Programs

Constructs		UND	MAS	APP	DEV
Gender					
Female	Mean	4.20	3.96	3.97	3.87
	SD	.57	.69	.65	.69
Male	Mean	4.09	3.88	3.95	3.71
	SD	.54	.71	.71	.73
Program					
BCAED	Mean	4.54	3.94	4.04	3.74
	SD	.47	.65	.50	.72
BEED	Mean	4.00	3.61	3.60	3.50
	SD	.64	.92	.87	.73
BPED	Mean	4.11	3.98	4.06	4.03
	SD	.50	.53	.58	.50
BSED Math	Mean	3.87	3.58	3.62	3.31
	SD	.61	.66	.64	.91
BSED Science	Mean	4.46	4.45	4.32	4.08
	SD	.53	.59	.55	.51
BTLED	Mean	4.15	4.02	4.10	4.07
	SD	.39	.52	.50	.55
BTVTED	Mean	4.26	4.11	4.16	4.01
	SD	.47	.40	.38	.69

Note: UND = Understanding of Knowledge; MAS = Mastery of Skills; APP = Application of Skills; DEV = Skills Development; SD = Standard Deviation; BCAED = Bachelor of Culture and Arts Education; BEED = Bachelor of Elementary Education; BPED = Bachelor of Physical Education; BSED = Bachelor of Secondary Education; BTLED = Bachelor of Technology and Livelihood Education; BTVTED = Bachelor of Technical-Vocational Teacher Education.

Table 2: Independent Samples t-test for Gender Differences Across Constructs

Constructs	Statistics	df1	p values
Understanding of Knowledge	1.34	201	.18
Mastery of Skills	.74	201	.46
Application of Skills	.16	201	.88
Skills Development	1.53	201	.13

Note: *p < .05; **p < .01; ***p < .001

Table 2 presents the results of the independent-samples t-test comparing male and female respondents across the four constructs. The p-values are greater than .05, indicating no statistically significant differences between male and female participants in their responses to the four constructs.

Table 3 presents the results of Welch’s one-way ANOVA conducted to examine differences among academic programs across the four constructs. The findings revealed statistically significant

differences across programs for understanding of knowledge, $F(6, 77.6) = 4.70, p < .001$; mastery of skills, $F(6, 78.3) = 5.12, p < .001$; application of skills, $F(6, 79.3) = 4.69, p < .001$; and skills development, $F(6, 76.1) = 5.17, p < .001$. The effect sizes ranged from $\eta^2 = .133$ to $.161$ and $\omega^2 = .106$ to $.135$, which indicate close to large effects across the constructs. Among the four constructs, skills development demonstrated the largest observed effect sizes ($\eta^2 = .161, \omega^2 = .135$).

Table 3: One-way ANOVA (Welch’s) for Program Differences Across Constructs

Constructs	F	df1	df2	p values	η^2	ω^2
Understanding of Knowledge	4.70	6	77.6	<.001***	.133	.106
Mastery of Skills	5.12	6	78.3	<.001***	.148	.121
Application of Skills	4.69	6	79.3	<.001***	.149	.122
Skills Development	5.17	6	76.1	<.001***	.161	.135

Note: *p < .05; **p < .01; ***p < .001; η^2 = eta-squared; ω^2 = omega-squared.

Table 4: Games-Howell Post-hoc Test Results

Programs		Mean Difference	p values	Cohen's d
Understanding of Knowledge				
BCAED	BEED	.536	.006**	.911
BCAED	BPED	.429	.028*	.877
BCAED	BSED Math	.667	.005**	1.231
BCAED	BTLED	.390	.045*	.927
BEED	BSED Science	-.458	.037*	-.763
BSED Math	BSED Science	-.589	.021*	-1.041
Mastery of Skills				
BEED	BSED Science	-.834	<.001***	-1.021
BEED	BTVTED	-.500	.045*	-.637
BSED Math	BSED Science	-.865	<.001***	-1.384
BSED Math	BTVTED	-.530	.048*	-.975
Application of Skills				
BEED	BSED Science	-.721	.002**	-.935
BEED	BTLED	-.503	.034*	-.682
BEED	BTVTED	-.557	.01*	-.750
BSED Math	BSED Science	-.704	.006**	-1.181
BSED Math	BTVTED	-.540	.031*	-1.030
Skills Development				
BEED	BPED	-.525	.004**	-.831
BEED	BSED Science	-.583	.005**	-.879
BEED	BTLED	-.573	.004**	-.866
BPED	BSED Math	.715	.001**	1.076
BSED Math	BSED Science	-.774	.024*	-1.071
BSED Math	BTLED	-.763	.024*	-1.074

Note: * $p < .05$; ** $p < .01$; *** $p < .001$; BCAED = Bachelor of Culture and Arts Education; BEED = Bachelor of Elementary Education; BPED = Bachelor of Physical Education; BSED = Bachelor of Secondary Education; BTLED = Bachelor of Technology and Livelihood Education; BTVTED = Bachelor of Technical-Vocational Teacher Education.

Table 4 provides the results of the Games-Howell post-hoc test following Welch's one-way ANOVA. This post hoc test was conducted to determine which academic programs differed significantly from one another across the four constructs. The results indicate significant pairwise differences across various program comparisons, as evidenced by the mean differences and corresponding p-values. For Understanding of Knowledge, BCAED scored significantly higher than BEED ($p = .006$, $d = .911$), BPED ($p = .028$, $d = .877$), BSED Math ($p = .005$, $d = 1.231$), and BTLED ($p = .045$, $d = .927$), with effect sizes ranging from large to very large. BEED also scored significantly lower than BSED Science ($p = .037$, $d = -.763$), while BSED Math scored lower than BSED Science ($p = .021$, $d = -1.041$), indicating moderate to very large differences favoring BSED Science.

In Mastery of Skills, BSED Science significantly outperformed both BEED ($p < .001$, $d = -1.021$) and BSED Math ($p < .001$, $d = -1.384$), with very large

effect sizes. Likewise, BTVTED scored significantly higher than BEED ($p = .045$, $d = -.637$) and BSED Math ($p = .048$, $d = -.975$), suggesting moderate to large practical differences between programs.

Similar patterns emerged in Application of Skills. BSED Science scored significantly higher than BEED ($p = .002$, $d = -.935$) and BSED Math ($p = .006$, $d = -1.181$), while BTVTED also outperformed BEED ($p = .01$, $d = -.750$) and BSED Math ($p = .031$, $d = -1.030$). Additionally, BTLED demonstrated significantly higher scores than BEED ($p = .034$, $d = -.682$). The observed effect sizes ranged from moderate to very large, indicating substantial program-related differences in the practical application of green skills.

For Skills Development, BEED scored significantly lower than BPED ($p = .004$, $d = -.831$), BSED Science ($p = .005$, $d = -.879$), and BTLED ($p = .004$, $d = -.866$), all reflecting large effect sizes. Moreover, BSED Math scored significantly lower than BPED ($p = .001$, $d = 1.076$), BSED Science ($p =$

.024, $d = -1.071$), and BTLED ($p = .024$, $d = -1.074$), with very large effect sizes observed in most comparisons.

Discussion

This study examined differences in green skills across gender and academic programs to determine whether competencies in sustainability-oriented practices vary among preservice teachers. The results showed no significant differences between male and female students, but notable variations emerged across programs, suggesting that curricular orientation and training experiences shape the development of green skills more than gender does. These findings highlight the importance of program-specific approaches in fostering sustainability competencies in teacher education.

Gender Differences in Green Skills

The findings of the independent samples t-tests revealed no statistically significant gender differences across all measured constructs: understanding of knowledge, mastery of skills, application of skills, and skills development. Although mean differences were observed, the p-values indicate that these variations are not large enough to be considered meaningful at the conventional significance level of .05. This suggests that both male and female participants demonstrated comparable levels of knowledge, skills mastery, application, and developmental progress in the context of the study. These results align with recent scholarship suggesting that gender gaps in educational performance are narrowing, particularly in learning environments that promote equitable participation and access to resources (25, 26).

The lack of significant gender differences also suggests that structural and pedagogical interventions in education may have mitigated previously reported disparities. Prior research indicated that males often outperformed females in technical or skills-based domains, while females tended to excel in verbal or knowledge-based assessments (27, 28). However, in the present findings, neither gender showed an advantage, which may reflect the growing influence of inclusive teaching practices, gender-sensitive curricula, and policies that support equal opportunities in skill development. Moreover, it reinforces arguments that individual learner

differences, rather than gender per se, may play a more critical role in shaping achievement outcomes (29).

Green Skills Across Teacher Education Programs

The results of Welch's ANOVA indicate that students' program affiliation significantly influenced their performance across all constructs: understanding of knowledge, mastery of skills, application of skills, and skills development. The omnibus tests were all highly significant ($p < .001$), confirming that at least one program differed from others on each construct. This suggests that while all programs aim to foster comparable competencies, the ways these competencies are developed and reinforced vary by academic specialization. These findings highlight the structural and curricular distinctions among teacher education programs, which may account for differences in emphasis on cognitive, psychomotor, and developmental learning domains.

The post hoc comparisons provide a more nuanced understanding of these program-based differences. For instance, BCAED students consistently outperformed several other groups in understanding of knowledge, particularly when compared to BEED, BPED, BSED Math, and BTLED students. Similarly, significant differences in skill mastery were observed, with BEED and BSED Math students scoring lower than their BSED Science and BTVTED counterparts. In terms of application of skills, BEED and BSED Math students also showed weaker performance compared to BSED Science, BTLED, and BTVTED students. For skills development, BEED students scored lower than multiple groups, while BPED students scored lower than BSED Math students. Taken together, these results suggest that some programs foster more consistent gains in specific competencies, reflecting variations in program design and training focus.

The disparities observed across programs can be understood within the broader literature on disciplinary orientations in teacher education. Prior research has shown that programs with strong laboratory- or practicum-based components often yield higher skill mastery and application outcomes compared to those with primarily content-driven curricula (30, 31). The observed differences in green skills among

students in BTLED, BTVTED, and BSED Science programs may be explained in relation to the intended curricular orientations outlined in the CHED program specifications. BTLED and BTVTED programs, as defined in the CHED Policies, Standards and Guidelines (PSGs), emphasize hands-on, technical, and livelihood-oriented training that exposes students to resource efficiency, waste management, and sustainable practices in real-world contexts (32, 33). In contrast, BSED Science students are exposed to environmental and scientific concepts that promote awareness of sustainability issues and responsible environmental practices (19). Conversely, BEED and BSED Math, which are more heavily oriented toward foundational content delivery, may place less emphasis on the applied and developmental dimensions of learning, thereby contributing to comparatively lower outcomes in these constructs (18, 19).

Implications

These findings carry important implications for teacher education policy and practice. The observed variations across academic programs suggest that opportunities for developing green skills may not be experienced uniformly among pre-service teachers. Such differences may reflect variations in curricular emphasis, learning experiences, exposure to sustainability-related concepts, and the extent of practice-oriented instruction embedded within each specialization. Programs with stronger performance in applied dimensions may benefit from reinforcing theoretical and conceptual foundations, while programs with comparatively lower performance may require closer examination of how sustainability-related competencies are contextualized within teaching and learning experiences.

The findings also highlight the importance of viewing green skills as multidimensional competencies that extend beyond environmental awareness alone. Developing these competencies requires integrating knowledge, practical application, problem-solving, adaptability, and responsible professional practice within teacher education programs. As future educators, pre-service teachers are expected not only to understand sustainability concepts but also to translate them into classroom practices and learning environments that respond to

contemporary educational and environmental challenges. Thus, the study underscores the broader role of teacher education institutions in fostering graduates who are environmentally conscious, pedagogically responsive, and capable of addressing the evolving demands of 21st-century education (31, 34).

Conclusion

The analysis underscores that the cultivation of green skills in preservice teachers is shaped more by the academic pathways they pursue than by gender identity. What emerges is a picture of teacher education programs as distinct learning environments, each privileging particular emphases on knowledge, practice, and application. Some programs appear to offer richer opportunities for experiential engagement and skill transfer, while others remain grounded in content-driven orientations. This uneven landscape signals that the quest for green skills and sustainability education cannot rely on a uniform approach; rather, it requires careful alignment of curricular design, pedagogical strategies, and program goals. Taken collectively, the findings suggest that advancing green skills in teacher education depends on embedding green skills and sustainability principles across disciplines in ways that are both contextually relevant and pedagogically meaningful.

Given that program-level factors appear to shape the development of green skills, teacher education institutions may revisit their curricula to ensure that green skills and sustainability competencies are meaningfully embedded across all specializations. Programs that are currently more content-oriented, such as elementary and mathematics education, may benefit from integrating experiential, project-based, and community-engaged learning opportunities that allow students to apply sustainability principles in authentic contexts. Faculty development may be prioritized to equip instructors with pedagogical strategies to infuse green skills into both theory and practice. Partnerships with local communities, government agencies, and industry may further strengthen the contextual relevance of sustainability training.

One limitation of the present study lies in its reliance on self-reported measures, which capture how participants perceive their competencies

rather than how these competencies are enacted in actual teaching contexts. Incorporating classroom observations, teaching demonstrations, portfolio assessments, or other performance-based measures in succeeding studies may offer a more grounded picture of how green skills are practiced and applied. The study also did not explore the learning experiences within teacher education programs that may shape these competencies. Examining instructional approaches such as service-learning, interdisciplinary activities, or problem-based tasks could provide deeper insight into how sustainability-oriented skills are cultivated among preservice teachers. Since the research was conducted at a single point in time, it likewise cannot account for how these competencies develop throughout teacher preparation and into professional practice. Longitudinal inquiries may therefore help illuminate how green skills emerge, strengthen, or shift over time. Moreover, the analysis focused primarily on differences across academic programs and did not fully consider the broader institutional and personal conditions that may influence sustainability learning. Future work may benefit from looking into factors such as institutional support systems, environmental attitudes, and socio-economic contexts. Qualitative or mixed-methods approaches may also enrich current findings by capturing the lived experiences, perspectives, and everyday practices of preservice teachers as they navigate sustainability education in diverse learning environments. Further, researchers may conduct multi-institutional studies across different regions in the Philippines and Southeast Asia to determine whether the findings of the present study reflect institution-specific conditions or broader systemic patterns in teacher education and green skills development. Such comparative studies may also provide deeper insights into how institutional and national contexts influence the integration of sustainability-oriented competencies in teacher preparation programs. Moreover, the findings suggest the potential value of developing instructional resources to enhance green skills among pre-service teachers. While the present study did not evaluate the effectiveness of the intervention, the identified patterns indicate

opportunities for future initiatives to integrate sustainability-related competencies into teacher education. One possible direction is the development and pilot testing of learning modules focused on environmental awareness, sustainable classroom practices, resource management, waste reduction initiatives, and climate-responsive pedagogy. Such modules may incorporate structured and practice-oriented activities that allow students to engage with sustainability concepts in realistic educational contexts.

Future research may also explore the use of digitized learning modules as a strategy to support green skill development. Digital platforms can provide interactive content, simulations, multimedia demonstrations, and collaborative learning experiences that may encourage inquiry and problem-solving. In addition, digital delivery may offer flexible access and integration opportunities within existing learning management systems. Examining how these features influence both sustainability-related competencies and digital literacy may provide valuable insights for teacher education programs. Experimental or quasi-experimental studies may also be utilized to evaluate the effectiveness of environmental education programs and sustainability-based instructional interventions in improving green skills among pre-service teachers.

Abbreviations

None.

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Author Contributions

Louie Paul D Fulminar: Conceptualization, Data Collection, Data Analysis, Methodology, Writing Original Draft, Proofreading, Editing, Mary Jean P Yanger: Conceptualization, Writing Original Draft, Proofreading, Editing, Bryan H Gervacio: Writing Original Draft, Ricky P Alalid: Writing Original Draft, Richard S Brun: Data Analysis, Mary Grace H Aruta: Proofreading, Editing.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

Generative AI tools were used to assist in language editing, organization, and formatting under the authors' full supervision. The authors take full responsibility for the content's originality, interpretation and accuracy.

Ethics Approval

This study was carried out in compliance with the ethics policy of the institution where we collected data. The research protocol was approved by the Head of the Institution. All the participants in the study provided informed consent.

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